

Notes on some species of the genus *Protosticta* from Vietnam (Odonata, Platystictidae)

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Based on a study of various recent collections of *Protosticta* Selys from Vietnam, the dragonfly species *P. grandis* Asahina and *P. khaosoidaoensis* Asahina (sensu stricto) are reported from Vietnam for the first time. New records are provided for *P. satoi* Asahina (new status), and the affinities of *P. satoi* and *P. beaumonti* Wilson are discussed. The status of a very dark form of *Protosticta satoi* found in Tam Dao (northern Vietnam) is also discussed. Two species from Chu Yang Sin National Park (southern Vietnam, Dak Lak province) are described as new to science, viz. *P. caroli* spec. nov. and *P. linnaei* spec. nov.

Introduction

Recent studies in the odonate family Platystictidae have revealed an astonishing diversity at the species level. The diversity of the fauna of Latin America was comprehensively described as early as the first half of the 20th century (e.g. Calvert, 1931; Kennedy, 1938, 1942), and less than ten new species have been described during the last 25 years (e.g. Brooks, 1989; Donnelly, 1992; De Marmels, 1989).

The diversity of the fauna of South-east Asia, however, appeared to be far more diverse than expected until recently, with forty species as new to science in the genus *Drepanosticta* Laidlaw alone since 1990 (van Tol, 2007a). Although most species were described from the Philippines (e.g. van Tol, 2005), Sulawesi (van Tol, 2007c), the Moluccas (van Tol, 2007b) and New Guinea (Theischinger & Richards, 2005), the family appeared to be also much more speciose in the mainland of South-east Asia. New species were discovered in Thailand (Asahina, 1984; Hämäläinen, 1999), Hong Kong and southern China (Zhou, 1986; Wilson, 1997; Wilson & Reels, 2001, 2003; Wilson & Xu, 2007).

Most species of Oriental Platystictidae are assigned to *Drepanosticta* and more than one hundred species are presently known. The genus *Platysticta* Selys is restricted to Sri Lanka and southern India, the recently described genera *Sinosticta* Wilson and *Sulcosticta* van Tol are confined to southern China and the Philippines, respectively. Finally, the genus *Protosticta* Selys as presently defined takes an intermediate position. It is rather widespread in the mainland of South-east Asia (Table 1) and occurs in the Philippines, Borneo and Sulawesi with 38 species. However, its monophyly is uncertain (van Tol, 2005), since the genus is based on the reduction of the anal crossing in the wing venation, a character susceptible to homoplasy. A phylogenetic study based on a wide variety of morphological and molecular characters is in progress (van Tol, in prep.). It seems unlikely that the species of the mainland form a monophyletic group with the type species of the genus *Protosticta*, *P. simplicinervis* Selys, and with other species from Sulawesi.

Table 1. Distribution of the species of *Protosticta* in mainland South-east Asia. References to all original descriptions are included in the references section.

Species of <i>Protosticta</i>	Distribution
<i>P. antelopoides</i> Fraser, 1931a	India (Travancore)
<i>P. beaumonti</i> Wilson, 1997	Hong Kong; China (Guangdong)
<i>P. caroli</i> spec. nov.	Vietnam
<i>P. curiosa</i> Fraser, 1934	Lower Burma (East Mergui); Thailand (widespread in western part)
<i>P. damacornu</i> Terzani & Carletti, 1998	NE India (Meghalaya)
<i>P. davenporti</i> Fraser, 1931b	South India (Mudis Hills)
<i>P. foersteri</i> Laidlaw, 1902	Peninsular Malaysia
<i>P. fraseri</i> Kennedy, 1936	India (Assam)
<i>P. grandis</i> Asahina, 1985	
syn. <i>P. robusta</i> Asahina, 1984 [nec Fraser]	Thailand (Chang Mai), Vietnam
<i>P. gravelyi</i> Laidlaw, 1915	
syn. <i>P. mortoni</i> Fraser, 1924	
syn. <i>P. stevensi</i> Fraser, 1922	India (Cochin State; Coorg; Nilgiris)
<i>P. hearsayi</i> Fraser, 1922	India (Nilgiris)
<i>P. himalaica</i> Laidlaw, 1917	
syn. <i>P. lindgreni</i> Fraser, 1920	India (Pashok, Darjeeling)
<i>P. khaosoidaoensis</i> Asahina, 1984	Thailand (Chantaburi and Chiang Mai), Vietnam
<i>P. kiautai</i> Zhou, 1986	China (Zhejiang)
<i>P. medusa</i> Fraser, 1934	Lower Burma (East Mergui), western Thailand (Kanchanaburi and Tak)
<i>P. robusta</i> Fraser, 1933	Laos (Taweing)
<i>P. rufostigma</i> Kimmins, 1958	South India (Tinnevely Dt.)
<i>P. sanguinostigma</i> Fraser, 1922	
forma <i>cerinostigma</i> Fraser, 1924	South India (Nilgiris)
South India (Nilgiris)	
<i>P. satoi</i> Asahina, 1997	northern Vietnam
<i>P. taipokauensis</i> Asahina & Dudgeon, 1987	Hong Kong; ? China (Fujian)
<i>P. trilobata</i> Fraser, 1933	Laos (Muang Cha)
<i>P. uncata</i> Fraser, 1931b	Upper Burma (North Shan States)

Only one species of *Protosticta*, *P. khaosoidaoensis satoi* Asahina has been reported from Vietnam up to now (Asahina, 1997; Tsuda, 2000; Cuong & Hoa, 2007). More intensive collecting of Odonata in Vietnam during the last decades provided the opportunity to study new material of *Protosticta* from Vietnam. The present paper gives descriptions of two new species of *Protosticta* and enumerates new records of previously described species. This paper does not report on all specimens of *Protosticta* I have seen from Vietnam; some collections are incomplete or only consist of females and need further study.

This paper is part of a series of papers prepared by staff of the National Museum of Natural History Naturalis on the occasion of the 250th anniversary of zoological nomenclature on 1 January 2008. Zoological nomenclature starts with the tenth edition of Linnaeus' *Systema Naturae*, which is 'deemed to be published on 1 January 1758' (International Commission on Zoological Nomenclature, 1999).

The damselfly family Platystictidae was unknown to Linnaeus. This may be not surprising for a group with mainly small and inconspicuous species virtually confined to the tropics, but the first species was described and illustrated only fifteen years after 1758 (Drury, 1773). Although the type of *Libellula paulina*, now *Palaemnema paulina* (Drury) is lost, the name is still valid, since Calvert (1931) inferred the identity of the nominal taxon, which was generally accepted.

Material and methods

I have examined specimens available in the National Museum of Natural History Naturalis (Leiden, The Netherlands) (RMNH), which includes collections brought together by M.A. Liefstinck (specimens from India and Burma from the F.C. Fraser collection), M. Hämäläinen (Espoo, Finland) (specimens from Thailand, Laos) and myself (Thailand, Vietnam). H. Karube, via M. Hämäläinen, made material preserved in the Kanagawa Prefectural Museum, Odawara, Japan available for this study. K.D.P. Wilson donated specimens of *P. beaumonti* for comparison with the Vietnamese species.

The specimens were studied and photographed with a Leica MZ16A equipped with a Leica DFC500 camera, motor focusing and LAS auto-imaging software.

Terminology, also of wing venation, follows Watson & O'Farrell (1991).

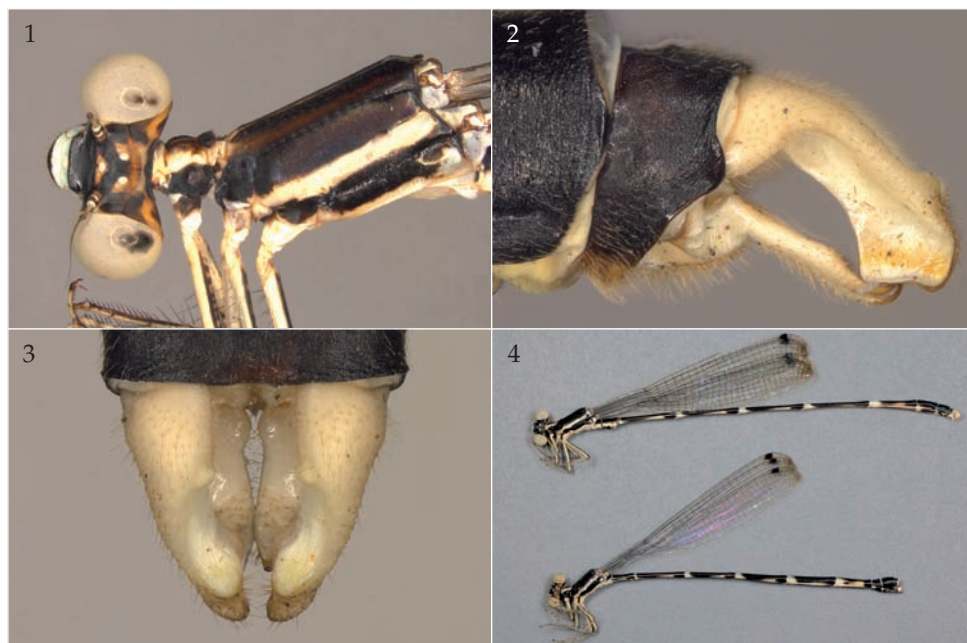
Platystictidae of Vietnam

Protosticta grandis Asahina (figs 1-4)

Protosticta robusta Asahina, 1984 [nec Fraser]: 590-591, 595, figs 16-20 (original description) [preoccupied].
Protosticta grandis Asahina, 1985: 334 (new name for *Protosticta robusta* Asahina, 1984).—Hämäläinen & Pinratana, 1999: 60 (distribution Thailand: Chiang Mai and Kanchanaburi); Tsuda, 2000: 326 (catalogued Thailand).

Material examined.—**Thailand:** Chiang Mai, Doi Suthep, 600 m, 29 March 2003, leg. M. Hämäläinen, 1 ♂, 1 ♀, in RMNH.—**Vietnam:** Vinh Phu province, Tam Dao, 1993, leg. H. Karube and collaborators, 3 ♀, in KPMO; same site, 16-17 May 1997, leg. H. Karube and collaborators, 1 ♀, in KPMO; Ninh Binh province, Cuc Phuong NP, 6 Jan. 1998, leg. H. Karube, 1 ♂, in KPMO; Dak Lak province, Chu Yang Sin National Park, small streams and seepages around confluence of Krong K'mar river and Ea Kchur river, ca. 12°28'N 108°20'E, 750 m asl, June 2007, leg. J. van Tol, 9 ♂ 1 ♀, in RMNH and IEBR; Lam Dong province, Bao Loc, various dates 1996-1998, leg. H. Karube and collaborators, 4 ♂ 4 ♀, in KPMO.

Protosticta grandis was extensively described by Asahina (1984), based on specimens from Chiang Mai, northern Thailand. It is also known from the Thai province of Kanchanaburi (Hämäläinen & Pinratana, 1999). Topotypical material from Thailand was compared with specimens collected in Burma, Laos and Vietnam. Although specimens from different sites show some variation, I consider the specimens from Vietnam mentioned above conspecific with the topotypical *Protosticta grandis*. Specimens from Tam Dao (females only) are larger than those of other sites (e.g. JvT 27971 from Tam Dao, abdomen 48 mm, hind wing 35 mm, as compared to JvT 26155, topotypical female from Chiang Mai, abdomen 41 mm, hind wing 30 mm). A specimen collected near Hue superficially resembles *P. grandis*, but presumably represents an undescribed species.



Figs 1-4. *Protosticta grandis* Asahina, male [JvT 28493, Vietnam, Chu Yang Sin National Park]. 1, head and synthorax, left lateral view. 2, anal appendages, left lateral view. 3, anal appendages, dorsal view. 4, habitus, male (above) and female (below). (Fig. 1: $\times 6$; 2-3: $\times 30$; 4: $\times 1$).

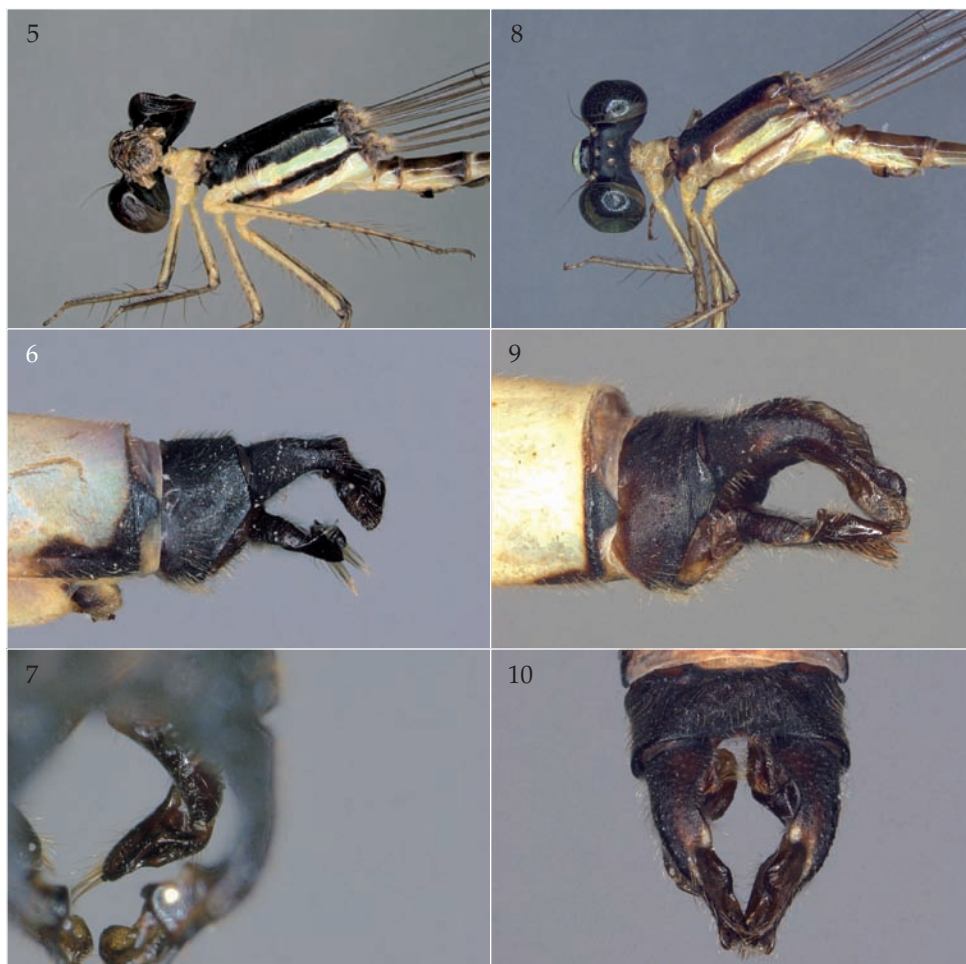
Based on morphological characters (see figs 1-3), *P. grandis* represents a clade only distantly related to the other species of Vietnam, which all belong to the *P. curiosa* or *P. beaumonti* groups. This observation was confirmed by a molecular study of about 490 bases pairs of the 16S gene, revealing a difference of tens of base pairs between *P. grandis* and other species described in this paper.

Remark.— The status of the specimens from Burma and Lao P.D.R. has not been ascertained; *P. grandis* has not been recorded from Burma and Lao P.D.R. before (Tsuda 2000).

***Protosticta khaosoidaoensis* Asahina**
(figs 5-10)

Protosticta khaosoidaoensis Asahina, 1984: 588-590, figs 8-15 (original description, type locality Thailand, Khao Soi Dao mountains).— Hämäläinen & Pinratana, 1999: 60 (distribution Thailand: Chiang Mai and Chanthaburi).

Material examined.— **Vietnam.** Nghe Tinh province. Huong Son district, west of Rao Qua: logging road along tributary of river An Bun. Rivulets, rocky stream and pools, dense logged forest and secondary growth. 100-150 m, 18°20'N 105°15'E, 2 July 1990, F.G. Rozendaal, 2 ♂ [JvT 1144-5], in RMNH; Nghe Tinh province, Ky Son district. Forest stream Khe Thuong, a tributary of river Song Ca. Primary forest. Altitude ca. 500 m, ca. 19°15'N 104°23'E. 8 July 1990. Leg. F.G. Rozendaal, 1 ♂ [JvT 1146], in RMNH; Nghe Tinh province, Thang Chuong district. Doi Khe Lao. Several streams through logged forest. ca. 100 m, 18°40'N 105°15'E, 11-12 July 1990, F.G. Rozendaal, 2 ♂ [JvT 1147-8], in RMNH.



Figs 5-10. *Protosticta khaosoidaoensis* Asahina, male [figs 5-7, Northern Thailand, Chiang Mai, Doi Suthep (JvT 19422). figs 8-10, Vietnam, Nghe Tinh province, Huong Son district, 1990 (JvT 1145)]. 5 and 8, head and synthorax, left lateral view. 6 and 9, anal appendages, left lateral view. 7 and 10, right inferior appendage, dorsal view (detail). (Figs 5, 8: $\times 6$; 6, 9, 10: $\times 30$; 7: $\times 50$).

Specimens from the Huong Son district of the Nghe Tinh province (now province of Ha Tinh) structurally resemble *P. curiosa* Fraser, but show characters of *Protosticta khaosoidaoensis* sensu stricto as defined by Asahina, especially in the coloration of the pronotum. A male from Thailand (Chiang Mai) is illustrated in figs 5-7, a male from Vietnam in figs 8-10. The inferior appendages lack the cup-like structures of *Protosticta linnaei* spec. nov., as described below.

It is uncertain whether *P. curiosa* and *P. khaosoidaoensis* indeed represent two different taxa, since structural differences seem to be small. For a better judgment, more material from Burma, Laos and Cambodia should be studied.

Protosticta satoi Asahina, **new status**
(fig. 16)

Protosticta khaoisoidaensis satoi Asahina, 1997 [June]: 108-109, figs 3-4 (original description, type locality [Vietnam], Tam Dao, 960 m, 21 May 1995).— Tsuda, 2000: 326 (catalogued Vietnam)

Protosticta khaoisoidaensis nec Asahina; Cuong & Hoa, 1997: 65 (distribution map).

? *Protosticta beaumonti* Wilson, 1997 [March]: 57-59, figs 11-16 (original description, type locality Hong Kong, Lantau, 22 May 1994, in BMNH).— Tsuda, 2000: 305 (catalogued China).

Material examined.— **Vietnam:** Ninh Binh province, Cuc Phuong National Park, 1994-1998, leg. H. Karube and collaborators, 12 ♂ 3 ♀ (in KPMO).

Description.— Male [Vietnam, Ninh Binh province, Cuc Phuong NP, 30 Apr 1994, H. Karube, JvT 27950, in KPMO] (colours of preserved specimen).

Head.— Labium, including lateral lobes, dirty white, distal half of lateral lobes with setae nearly as long as lobe itself; labrum bluish-white, anterior one-fifth black; mandibles black with triangular bluish-white spot adjoining labrum, the anterior black stripe of mandibles much wider than stripe on labrum; anteclypeus bluish-white, postclypeus brown, rest of head black with some metallic sheen, fine coriaceous around ocelli, but area around eyes shining; scapus brown, pedicellus with basal three-quarters ivory white, rest of pedicellus brown, flagellum brown; transverse occipital carina just discernable, without lateral extremities.

Thorax.— Pronotum with anterior and posterior lobes simple, without distinct lateral or posterior processes; yellowish white, but medially on posterior lobe a trapezoid dark marking. Synthorax with mesepisternum brownish-black with metallic sheen; mesepimeron pale brown; metepisternum largely dirty yellow; upper side of mesokatepisternum brown, lower side dirty yellow, central part brownish black; metepimeron and metakatepisternum pale; venter yellowish-white. Legs yellowish-white, but outer surface of all femora and basal half of tibiae with narrow black lines. Wings clear with venation brown; Px 15 in fore wing, Px 14 in hind wing; R4+5 arising distinctly distal to Ax2; Ab vein missing; CuP meeting hind margin of fore wing at Px3, of hind wing at Px 4; number of cells between Arculus and place where CuP meets hind margin of fore wing 6, of hind wing 7; R3 arising in hind wing at level of Px 6; pterostigma trapezoid.

Abdomen.— First six segments relatively pale, base colour dirty yellow, rest of abdomen darker, except segment 9; segment 1 pale with inconspicuous dorsal trapezoid brown marking, segment 2 also with dorsal brown marking and oblong ivory white markings in latero-anterior corners; segments 3-6 brownish, each segment anteriorly with short and narrow yellow marking, ca. one-fifth of each segment; segment 7 anteriorly pale brown, posterior three-quarters dark brown; segment 8 brownish black; segment 9 ivory white with narrow black line anteriorly adjoining intersegmental ring; segment 10 brownish-black. Anal appendages (fig. 16) brownish black, superiors ca. 2 times length of segment 10 of abdomen; basal half stout, cylindrical and tapering; distal half compressed with short dorsal tooth; inferiors basally diverging, distal half with oblong triangular shape, terminally pointed and provided with tuft of setae, dorsal surface with of terminal part with cup-shaped structure, with terminal spine bent abaxiad.

Measurements.— Abdomen, including appendages, 44 mm, hind wing 21 mm.

Remarks.— The rather incomplete description of *P. khaosoidaoensis satoi* Asahina is based on one female from Tam Dao. The collections of *Protosticta* from Tam Dao before me (KPMO, RMNH / IEBR), however, do not contain further specimens comparable to the description of this nominal taxon. Presuming that the measurements of ‘subspecies’ *satoi* are comparable to the nominate *P. khaosoidaoensis*, the abdomen of the male should be about 37–38 mm and the hind wing 19–20 mm. The coloration of the synthorax of *P. satoi* (pale brown mesepimeron, dirty yellow metepisternum and metepimeron with a fine stripe over metapleural suture), as well as the pale blue marking mesoposteriorly on segment 9 of the abdomen, are markedly different from the same structures in *P. khaosoidaoensis sensu stricto*.

However, I consider female *Protosticta* specimens from Cuc Phuong National Park (see material section) to be *P. satoi* (new status), since they agree with the description and illustrations of this taxon (Asahina, 1997). Males from the same locality, with similar synthorax as the females, are structurally similar to topotypical *P. beaumonti* Wilson (RMNH, ex coll. Wilson) (see description above, and figs 16 and 17). The abdomen, including anal appendages, of males of *P. beaumonti* measure 44–45 mm, the hind wings 22–22.5 mm. The abdomen of males from Cuc Phuong measure ca. 44–45 mm, the hind wings 20–22 mm. Further studies (see also below) should reveal whether *P. satoi* is a junior synonym of *P. beaumonti*, or whether both represent distinct species.

Protosticta satoi dark form
(figs 11–15)

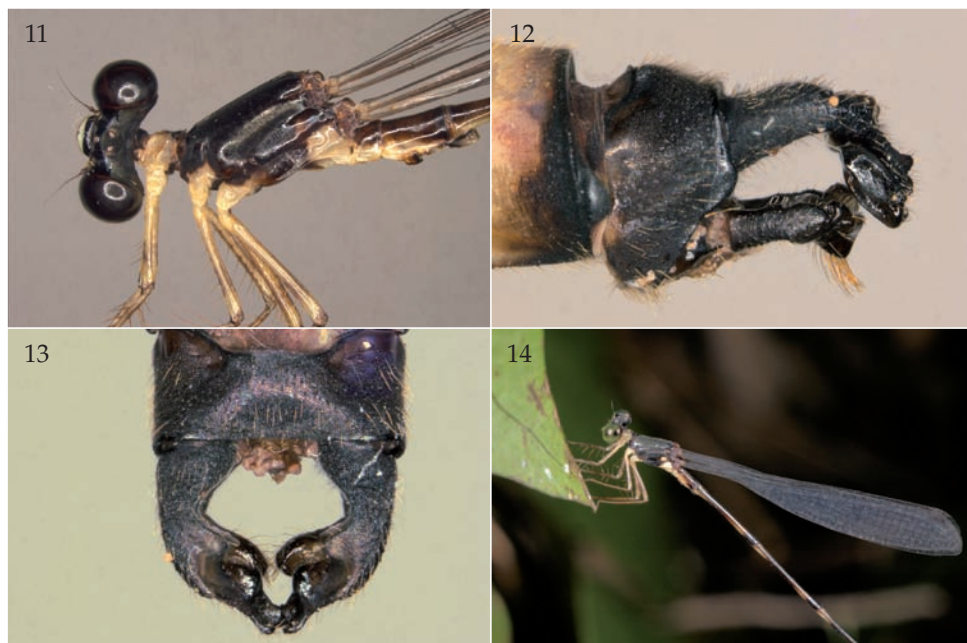
? *Protosticta beaumonti*.— Wilson & Reels 2003: 273–275, figs 114–120 (dark form from W Guangxi, Did-ing).

Material examined.— Vietnam, Vinh Phu province, Tam Dao: 1993–1994, leg. H. Karube, 3 ♂, 2 ♀, in KPMO; idem, 30 May 1997, leg. H. Karube, 1 ♂, in KPMO; idem, various streams around village, including crossing road to Tamdao 2, 13–15 May 2007, leg. J. van Tol 10 ♂ 1 ♀, in RMNH and IEBR.

Description.— Male [based on JvT 28703] (see also fig. 14).

Head.— Labium dirty yellow, lateral lobes distal half pale brown with setae nearly as long as lateral lobe itself; labrum bluish-white, anterior two-fifths black; mandibles black with triangular bluish-white spot in inner basal corner; anteclypeus bluish-white, rest of head dark black, fine coriaceous with longitudinal striae, but area around eyes shining; scapus dark brown, pedicellus basal half dirty white, distal half brown, flagellum broken off in type [brownish black in other specimens]; transverse occipital carina just discernable, without lateral extremities.

Thorax.— Pronotum with anterior and posterior lobes simple, without distinct lateral or posterior processes; base colour yellowish-white, with black markings as follows: anterior lobe black, median lobe with paired protuberance brownish black, medially darker; lateral lobes yellowish white; posterior lobe black, but lateral corners dirty yellow. Synthorax (fig. 11) very dark brownish black with some metallic sheen, but lower posterior corners of mesokatepisternum and metakatepisternum, and posterior half of metepimeron, yellowish-white; venter distinctly bicolorous, anteriorly brownish black, posteriorly yellowish white as continuation of pale markings of



Figs 11-14. *Protosticta satoi* dark form, male [JvT 28748 (figs 11-13, Vietnam, Tam Dao, 2007). 11, head and synthorax, left lateral view. 12, anal appendages, left lateral view. 13, anal appendages, dorsal view. 14, living male, northern Vietnam, Tam Dao, 2007. (Fig. 11: $\times 6$; 12-13: $\times 30$).

metepimeron. Legs yellowish-white, but rims on outer surface of all femora dark. Wings clear with dark brown venation, basally middle brown; Px 16 in fore wing, Px 15 in hind wing; R4+5 arising at subnodus; Arculus arising just distal to Ax2; Ab vein missing; CuP meeting hind margin of fore wing at level of Px3, of hind wing at Px4; number of cells between Arculus and place where CuP meets hind margin of fore wing 6, of hind wing 8; R3 arising in hind wing at level of Px7; pterostigma trapezoid, the proximal and basal veins convex, 1.0 mm wide, 0.6 mm high; dark brown, but bordered with narrow white line against veins; cells between Costa and R1 distal to pterostigma undivided.

Abdomen.— Brownish black and middle brown; segment 1 dorsally with brown marking covering ca. three-fifths of segment width, rest of segment pale; segment 2 nearly fully brown, somewhat darker along posterior margin, with oblong triangular pale marking in latero-anterior corner, ca. three times as long as high; segments 3-5 brown, but paler anterior markings of ca. one-eighth of segment length just behind anterior margin, and other pale markings of ca. one-sixth of segment-length ca. one-sixth of segment-length from posterior margin; segments 6-7 as 3-5, but without posterior pale markings; segment 8 dorsally brownish black, with small triangular markings in latero-anterior corners, ca. three-fifths length of segment; segment 9 pale ivory-white with narrow incomplete dark anterior margin and complete, dark posterior margin, laterally somewhat widening; segment 10 brownish black. Anal appendages (figs 12-13, 15) black; superiors ca. 2.0 times length of abdominal segment 10, basal half stout, cy-



Figs 15-17, Anal appendages male, postero-lateral view. 15, *P. satoi* dark form, Tam Dao. 16, *P. satoi*, northern Vietnam, Cuc Phuong. 17, *P. beaumonti*, Hong Kong. (all figs $\times 50$).

lindrical and tapering, distal half somewhat compressed, with stout dorsal tooth at base of compressed part, and a short protuberance ventrally at base of compressed part; distal half ventrally somewhat emarginate, distally rounded; inferiors in ventral view with bases ca. 60° diverging, and distal half bent axiad; terminal part more than two times as wide as base, club-shaped, ventrally with row of setae, terminally denser than at base, but not forming a distinct tuft; in posterior view a long and stout terminal spine, which is bent abaxiad, visible; dorsal side of inferiors cup-shaped, the cup placed fully terminally.

Measurements.— Abdomen, including appendages, 44 mm, hind wing 22 mm.

Female [JvT 28715].— As male, except for the following characters: median lobe of pronotum ivory-white without dark coloration; abdominal segment 4-6 anteriorly with ivory-white triangular markings, with base anteriorly adjoining intersegmental annulae, lateral to these markings in latero-anterior corner subrectangular pale markings, larger on each following segment, segment 7 anterior third bluish pale white with irregular margin with dark posterior two-thirds, segment 8 brownish-black with triangular pale marking in latero-anterior corner, segments 9-10 brownish-black, valve brownish-black, terebra ivory-white.

Measurements.— Abdomen 46 mm, hind wing 23 mm.

Variation.— The coloration of the pronotum of the males shows significant variation; the median lobe may be either fully pale coloured, or heavily smudged dark. Measurements: male abdomen, including appendages, 43-48 mm, hind wing 22-26 mm.



Fig. 18, Small stream at crossing road between Tamdao and Tamdao 2, June 2007. *Protosticta satoi* dark form can be found in dense vegetation immediately above the road, together with, e.g., *Devadatta ducatrix* Lieftinck, *Agriomorpha fusca* May, *Indocnemis ambigua* (Asahina) and *Coeliccia onoi* Asahina, while *Calicnemia erythromelas* (Selys) is most common at the sunny sites near the road.

Remarks.— Medium-sized *Protosticta* (fig. 14) with long abdomen and short wings; inferior appendages of males ending in cup-shaped structure, as in *P. satoi* Asahina, *P. beaumonti* Wilson (fig. 17) and *P. caroli* spec. nov., but can immediately be distinguished from other species by fully brownish-black synthorax without pale stripes and only a triangular posterior marking on the metepimeron. This may be the same taxon as recorded by Wilson & Reels (2003: 273-275) from western Guangxi, a province of China bordering Vietnam. As already stressed by Wilson & Reels (2003), the structural differences of the anal appendages and other diagnostic characters of these specimens with *P. beaumonti* are subtle. Apart from the remarkably unusual coloration, I only found significantly longer wings as a diagnostic character of the dark form of *P. beaumonti* or *P. satoi*. The hind wings of the dark form (Tam Dao) virtually reach to the posterior margin of segment 5 of the abdomen, and are 52-56% of the length of the abdomen (including anal appendages). The two males from Guangxi (*P. beaumonti*) agree with these figures (53-56%). The hind wing of specimens from Cuc Phuong, here identified as *P. satoi*, only reach to halfway segment 5 and are 47-48% of the length of the abdomen. Hind wings of topotypical specimens of *P. beaumonti* are also short, reach to halfway segment 5 and are 47-49% of the length of the abdomen.

A final judgment of the status of the populations from Tam Dao has to be postponed until more material is available, or results of a molecular study of at least *Protosticta beaumonti* can be compared with the specimens from Tam Dao, Cuc Phuong ('*satoi*') and

southern Vietnam ('*linnaei*'). A preliminary study of the 16 rDNA region (about 490 base pairs) revealed that specimens from Tam Dao differ in at least 18 base pairs from both *P. caroli* spec. nov. and *P. linnaei* spec. nov., indicating a larger difference than the difference between the last two mentioned species (about 9 base pairs), which differ considerably in structural characters.

Distribution.— Vietnam (Vinh Phu province): Tam Dao. Rather uncommon on small, steep rocky streams around the village (fig. 18). This mountain ridge is a national park, but at least the fauna of the streams in the immediate surroundings of the village is under threat, since all water sources are used for drinking water supply under the rapid development of the tourist sector in the park.

Descriptions of new species

Protosticta caroli spec. nov. (figs 19–22)

Type material.— Holotype ♂ [JvT 28496] in RMNH: 'Vietnam (Dak Lak province). Chu Yang Sin NP: stream with small brooklet and seepage in forested area. 12°31'03"N 108°17'41"E. Alt. 500 m. 7 Jun 2007. Leg. J. van Tol.'— Paratypes (9 specimens, in RMNH and IEBR): Bao Lok, 3–5 May 1997, leg. H. Karube, 2 ♂, in KPMO; Chu Yang Sin NP: small sandy forest stream (left bank just above dam in Krong K'mar river). 12°26'48"N 108°20'10"E. Alt. 760 m. 3, 8 and 10 Jun 2007, leg. J. van Tol, 5 ♂; same data as holotype, 1 ♂; same site, but 9 June 2007, 2 ♂.

Diagnosis. — Medium-sized, rather dark *Protosticta* of the *P. curiosa*-complex, but most closely related to *P. satoi* and *P. beaumonti* as defined above; males differ from *P. satoi* by the dark coloration of the prothorax (most specimens) and synthorax, a much smaller pale marking on segment 9 of the abdomen, and a larger cup-like structure of the appendix inferior; the terminal spine is smaller, although also distinctly curved axiad; distinct subterminal tuft of setae ventrally on appendix inferior.

Male [holotype, JvT 28496].— Head.— Labium dirty yellow, lateral lobes distal half pale brown with setae nearly as long as lateral lobe itself; labrum bluish-white, anterior two-fifths black; mandibles black with triangular bluish-white spot in inner basal corner; anteclypeus bluish-white, rest of head black, fine coriaceous with longitudinal striae, but area around eyes shining; scapus dark brown, pedicellus basal half dirty white, distal half brown, flagellum (broken in holotype) brownish-black; transverse occipital carina just discernable, without lateral extremities.

Thorax (fig. 19).— Pronotum with anterior and posterior lobes simple, without distinct lateral or posterior processes; base colour dirty yellowish-white, with black markings as follows: anterior lobe with median trapezoid spot, posterior side ca. one-third of posterior width of anterior lobe, median lobe with variegated brownish-black markings, but latero-anterior corner pale coloured; lateral lobes yellowish-white with narrow black stripe along dorsal and posterior margin; posterior lobe black. Synthorax dark brownish-black; mesepisternum and mesepimeron black; metepisternum dorsally with pale stripe, ca. three-fifths the height of metepisternum, more or less parallel-sided, continuing over mesokatepisternum; metepimeron dorsal half brownish-black, but pale ventral marking continuing along posterior margin; metakatepisternum dorsally black, ventral half pale. Legs yellowish-white, but outer surface of all femora, and tibiae



Figs 19-22. *Protosticta caroli* spec. nov., male [JvT 28519 (figs 19-21), Vietnam, Chu Yang Sin National Park, and JvT 28351 (fig. 22), same locality]. 19, head and synthorax, left lateral view. 20, anal appendages, left lateral view. 21, anal appendages, dorsal view. 22, ligula, oblique view. (Fig. 19: $\times 6$; 20-21: $\times 30$; 22: $\times 60$).

of fore and hind legs with narrow black lines. Wings clear with dark brown venation, basally middle brown; Px 14 in fore wing, Px 13 in hind wing; R4+5 arising distinctly distal to subnodus; Arculus just distal to Ax2; Ab vein missing; CuP meeting hind margin of fore wing at level of Px2, of hind wing at Px3; number of cells between Arculus and place where CuP meets hind margin of fore wing 5, of hind wing 6; R3 arising in hind wing at level of Px5; pterostigma subrectangular, 0.8 mm wide, 0.6 mm high; reddish-brown, but bordered with narrow white line against veins; cells between Costa and R1 distal to pterostigma undivided.

Abdomen.— Dark brown and yellowish-white; segment 1 dorsally with brown marking which is medially constricted, rest of segment pale; segment 2 nearly fully brown, with oblong pale marking in latero-anterior corner, ca. three times as long as high; segment 3 brown, with somewhat paler anterior ring against segment 2, posterior one-fifth distinctly darker; segments 4-6 brown, with oblong pale marking in latero-anterior corner against preceding segment, ca. four times longer than high (median part of each segment also paler brown), and distal one-fifth of each segment darker brown; segment 7 brown, gradually darker posteriorly, and a paler crescent-shaped spot in latero-anterior corner, ca. one-third length of segment; segment 8 dorsally dark brown, with large triangular markings in latero-anterior corners, ca. three-fifths length of segment; segment 9 dirty brownish-yellow, with triangular medio-anterior marking, ca. three-fifths length of segment, posterior one-sixth of segment dark brown, stripe somewhat widening towards corners; segment 10 brown. Anal appendages

black (figs 20-21); superiors ca. 2.0 times length of abdominal segment 10, basal half stout, cylindrical and tapering, distal half compressed, with short dorsal tooth at base of compressed part, and a short protuberance ventrally at base of compressed part; distal half ventrally somewhat emarginate, distally rounded; inferiors in ventral view forming a heart-shaped figure, bases ca. 60° diverging, and distal half again 60° bent axiad; terminal part more than two times as wide as base, club-shaped with distinct terminal tuft of setae; in posterior view a long and stout terminal spine, which is bent abaxiad, visible; dorsal side of inferiors cup-shaped, the cup placed fully terminally.

Measurements.— Abdomen, including anal appendages, 39 mm; hind wing 20.5 mm.

Female.— Unknown.

Variation.— Males from Chu Yang Sin National Park: abdomen, including anal appendages, in all specimens 45 mm; hind wing 22-23 mm.

Etymology.— Named for Carolus Linnaeus, founder of biological nomenclature, on the occasion of the 250th anniversary of zoological nomenclature (Linnaeus, 1758). *Caroli*, a noun in the genitive case.

Biology.— At small streams and seepages (see also fig. 12).

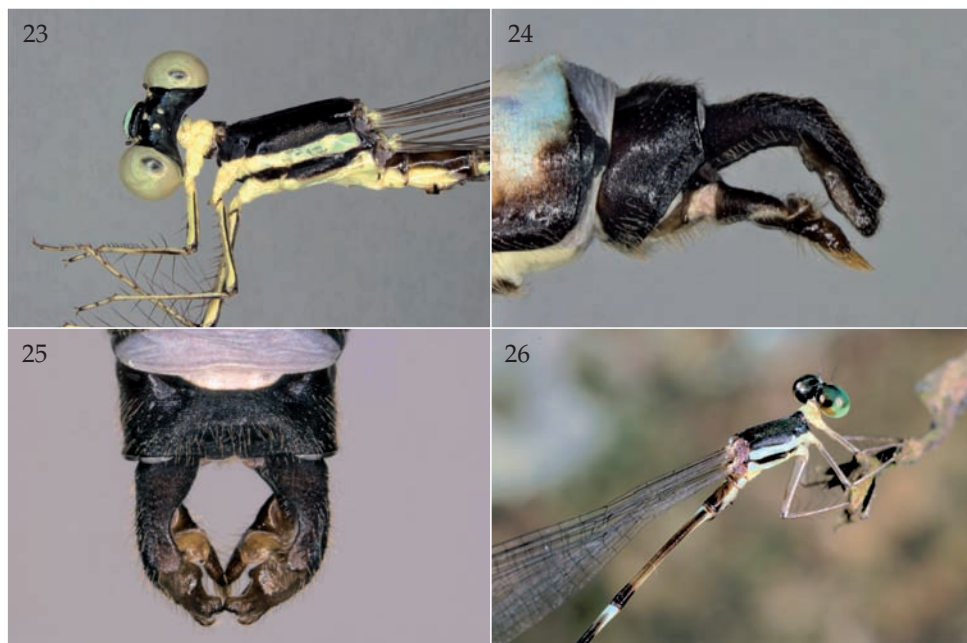
Distribution.— Southern Vietnam: Dak Lak province (Chu Yang Sin National Park), Lam Dong province (Bao Loc).

Protosticta linnaei spec. nov.
(figs 23-26)

Type material.— Holotype ♂ [JvT 28352]: 'Vietnam (Dak Lak province). Chu Yang Sin NP: small sandy forest stream (left bank just above dam in Krong K'mar river). 12°26'48"N 108°20'10"E. Alt. 760 m. 3 Jun 2007. Leg. J. van Tol', in RMNH.— Paratypes (9 ♂, in RMNH and IEBR) (all Vietnam, Dak Lak province, Chu Yang Sin National Park): Da K'mla river (left bank of Krong K'mar river just above hydro-electric dam under construction), small river in rather steep valley, rocks, boulders, pebbles and coarse sand, secondary forest, 12°26'51"N 108°20'09"E. Alt. 760 m. 2 Jun 2007. Leg. J. van Tol, 3 ♂; Same data as holotype, 2 ♂; Ea Kchur river near Thon 3. Small river, c. 8 m wide, steep valley, rocks, some pebbles and coarse sand (including a small muddy tributary); secondary vegetation, gardens, 12°28'32"N 108°17'33"E. Alt. 570 m. 6 Jun 2007. Leg. J. van Tol, 1 ♂; Stream with small brooklet and seepage in forested area, 12°31'03"N 108°17'41"E, Alt. 500 m, 7 Jun 2007, Leg. J. van Tol, 1 ♂; Sandy forest stream. 12°26'48"N 108°20'10"E. Alt. 760 m. 8 Jun 2007. Leg. J. van Tol, 2 ♂.

Diagnosis.— A slender *Protosticta* of the *P. curiosa* group (fig. 26) with short wings, dark base colour of head and thorax strongly contrasting with bluish-white markings; pale markings in comparison to *P. caroli* more extensive and distinct, also in live specimens; males with tip of inferior appendage elongate and tapering, with a subterminal cup-like structure on dorsal surface of inferiors. Differs from *P. curiosa* by the presence of a distinct cup-like structure on the dorsal side of the inferior appendage (see remarks below).

Male [holotype, JvT 28352].— Head.— Labium dirty white, median lobe very pale brown, lateral lobes dirty white, distal half with setae nearly as long as lateral lobe itself; labrum bluish-white, anterior two-fifths black; mandibles black with triangular bluish white spot adjoining labrum, the anterior black stripe as a continuation of the stripe over labrum; anteclypeus bluish-white, rest of head black with some metallic



Figs 23-26. *Protosticta linnaei* spec. nov., male [JvT 28302 (figs 23-25), Vietnam, Chu Yang Sin National Park, 2007]. 23, head and synthorax, left lateral view. 24, anal appendages, left lateral view. 25, anal appendages, dorsal view. 26, living male, southern Vietnam, Chu Yang Sin National Park, 2007. (Fig. 23: $\times 6$; 24-25: $\times 30$).

sheen, fine coriaceous with longitudinal striae, but area around eyes shining; scapus pale with some black markings, pedicellus basal half ivory-white, distal half brown, flagellum brown; transverse occipital carina just discernable, without lateral extremities. Eyes green in living individuals (fig. 26).

Thorax.—Pronotum with anterior and posterior lobes simple, without distinct lateral or posterior processes; base colour ivory-white, with markings as follows: anterior lobe with narrow brown stripe over anterior ridge, posterior lobe brownish-black but with narrow anterior and wider lateral pale stripes. Synthorax (fig. 23) brownish-black; mesepisternum and mesepimeron black; metepisternum dorsally with pale stripe, ca. four-fifths the height of metepisternum, more or less parallel-sided, continuing over mesokatepisternum and lower side over metastigma; metepimeron dorsal half brownish black, but pale ventral marking continuing along posterior margin; metakatepisternum dorsally black, ventral two-thirds pale; venter ivory-white. Legs yellowish-white but outer surface of all femora and basal half of tibiae with narrow black lines. Wings clear with brown venation; Px 13 in fore wing, Px 13 in hind wing; R4+5 arising at subnodus; Arculus just distal to Ax2; Ab vein missing; CuP meeting hind margin of fore wing at level of Px2, of hind wing at Px3; number of cells between Arculus and place where CuP meets hind margin of fore wing 5, of hind wing 6; R3 arising in hind wing at level of Px5; pterostigma subrectangular, 0.8 mm wide, 0.6 mm high; brown, but bordered with narrow white lines against veins; cells between Costa and R1 distal to pterostigma undivided.

Abdomen.— Dark brown and bluish-white markings with high contrast; segment 1 dorsally with brown marking, laterally concave, posterior side wider than anteriorly, rest of segment ivory-white; segment 2 nearly fully brown, medially somewhat paler, with oblong ivory-white marking in latero-anterior corner, ca. three times as long as high; segment 3 brown, anteriorly with short and narrow bluish-white marking sharply pointed posteriorly, brown marking paler posteriorly until reaching dark posterior ring adjoining posterior margin of segment; segments 4-7 brown, with somewhat irregular bluish-white basal markings, laterally covering anterior one-sixth, one-fifth, one-quarter and one-third of respective segments, posterior part of each segment somewhat darker than median part; segment 8 dorsally brownish-black, with large triangular markings in latero-anterior corners, ca. three-fifths length of segment; segment 9 bluish-white or ivory-white, with narrow stripe adjoining anterior intersegmental ring, latero-posterior corners black; segment 10 brownish black. Anal appendages (figs 24-25) black; superiors ca. 2.0 times length of abdominal segment 10, basal half stout, cylindrical and tapering, distal half compressed, with short dorsal tooth at base of compressed part, and a short protuberance ventrally at base of compressed part; distal half ventrally somewhat emarginate, distally distinctly bilobed; inferiors basally diverging, the distal half club-shaped and curved inwards, dorso-basally and subterminally on distal half a cup-shaped structure.

Measurements.— Abdomen, including appendages, 42 mm; hind wing 20 mm.

Variation.— Paratypes: abdomen, including appendages, 40-42 mm; hind wing 21-22 mm.

Female.— Unknown.

Remarks.— The relationship of this species with *P. curiosa* and *P. khaosoidaoensis* needs further study. Fraser (1934) does not mention a cup-like structure dorsally on the inferior appendage of the type specimen of *P. curiosa* (Lower Burma, East Mergui). Such a structure was also not illustrated nor described by Asahina (1984) for *P. curiosa* or *P. khaosoidaoensis*. It is not present in a specimen from Thailand (Kanchanaburi, 1-3 Oct 1986, leg. M. Hämäläinen, ex coll. M. Hämäläinen, now in RMNH, JvT 19432), nor in specimens from Vietnam mentioned under *P. khaosoidaoensis* (see above). All specimens are also characterized by extremely short hind wings (type 18 mm, Asahina specimens 18-21 mm, and the RMNH specimen 17 mm). The cup-like structure was, however, described and illustrated by Wilson & Reels (2003: fig. 113) based on a male *Protosticta* from Phuket (Thailand) identified as *P. curiosa*, which may indicate that *P. linnaei* occurs in Thailand as well.

Etymology.— Named for Carolus Linnaeus, founder of biological nomenclature, on the occasion of the 250th anniversary of zoological nomenclature (Linnaeus, 1758). *Linnaei*, a noun in the genitive case.

Biological notes.— Generally on larger streams than *P. caroli* spec. nov.

Distribution.— Southern Vietnam: Dak Lak province.

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